THE SLEEP OF PLANTS, AND CAUSE of MOTION IN THE SENSITIVE PLANT, EXPLAINED.

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In a LETTER to
LINNÆUS.

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Advertiſement.

THE public will pleaſe to excuſe any particularity of ſtyle in the ſucceeding pamphlet; ſince its appearance is accidental in this form. I promiſe myſelf ſo much indulgence from their candour, when they ſhall know it was originally intended to be no more than the title expreſſes; a private Letter to a foreign Naturaliſt.

There is a freedom of ſtyle, and aſſured manner peculiar to this kind of correſpondence, which would be too aſſuming in works addreſſed immediately to the public; and might not unnaturally draw upon the author a cenſure of ſelf-ſufficiency and vanity. This explanation, I hope, will defend me from ſo unfair a charge: for indeed no one knows more the narrow limits of human knowledge; or entertains an humbler opinion of the returns for years of application.

That the experiments which were the occaſion of writing it, have added their mite to the ſtores of ſcience, will be allowed; for it has not before been known, that thoſe changes which are brought on by night, in what are called the ſleeping plants, and in the ſenſitive by a touch, could be at our pleaſure occaſioned at any hour; and without the touch, or any other motion.

As this depends ſolely on removing the cauſe which kept them awake (ſo it is the faſhion to ſpeak), and expanded, it will be allowed alſo that cauſe, though hitherto undiſcovered, is known.

This is the utmoſt of the diſcovery; and from this I perſuade myſelf nothing can be taken.

The word Sleep, uſed on this occaſion, will, I am afraid, appear to the judicious Britiſh eye, an affected, as well as improper term: but the application of it lies at another's charge; and perhaps the manner of the country where he is native, will excuſe it. Having thus diſclaimed the word, I ſhall be pardoned for uſing it in the following diſcourſe, when the reader conſiders it as a private letter, written to the perſon who firſt adopted the expreſſion.

The preſerving that term, and publiſhing the whole with the particularities which gave occaſion to this apology, has been owing to a ſtrict regard to truth; which prompted me to lay the letter before the public unaltered, rather than amended: nor has the publication of it in England, where the taſte of ſcience is not general, any other motive, than to ſave the tediouſneſs of tranſcribing, for the uſe of a few, who have been pleaſed to flatter me by their deſire of preſerving the diſcovery in its original form.

TO THE CELEBRATED

LINNÆUS.

IT is not ſtrange to you to be addreſſed from remote countries; nor in the cauſe of ſcience can it be unwelcome.

Probably you have leſs expected this from me than any other; but I will not ſuppoſe you have leſs deſired it: The ſame purſuits have a long time engaged our attention; and it could not be that I ſhould paſs over your great name in ſilence. If our opinions have differed, 'tis upon a ſingle point; your arrangement of plants. In regard to that much greater article, the eſtabliſhing their diſtinctions, and aſcertaining their characters, I have always admired and reverenced you: to diſpute your determinations there, were to deny the characters of nature.

Free in the tribute of applauſe on this head, I have on the other been as open in my cenſures; equally uninfluenced by envy, and by fear. It is thus ſcience may be advanced; and you will permit me to ſay, thus men of candour ſhould treat one another. In this light I perſuade myſelf you have always ſeen my

my conduct toward you: that you have read with the same equal temper the censures of the *British* Herbal, wherein it came before me to examine systems; and the just applause of *Eden*, where the characters of genera, and distinctions of species were most to be considered; and that you will receive these impartial thoughts with more satisfaction, than all the little flattery of your pupils, or ignorant applause of those who have not understood your writings.

Systems are vague and unsubstantial; but those distinctions are invariable and everlasting: and many distributions may be formed upon the discoveries you have made of them. In this essential part of botany you have alone done more than all who wrote before you: and I am convinced you will entertain no enmity against me, who with equal freedom point out these excellencies, and what have appeared to me your imperfections; that you will read those censures with no more resentment than I wrote with malice; and will see on what foundation to build your fame: for I have often said, and the world will say it, your system is repugnant to nature, although your characters are her own.

This is the opinion I entertain of you; and in this confidence address to you the present treatise: an attempt to explain the cause of a quality in vegetables, whose effects none has observed with so much diligence or accuracy as yourself.

SEC-

SECTION I.

That the leaves of certain plants aſſume at night a diſpoſition different from that of the day, has been long known; *Acoſta* records it of the Tamarind; *Alpinus* of that tree, and of the *Abrus* *; and from theſe, all who followed: *Alpinus* extends the obſervation to ſeveral other of the *Egyptian* kinds; and you have carried it much farther among the *European*.

That Author conceived it a proviſion of nature for the defence of the nobler parts, the flowers and fruit: and he particularly obſerves of the Tamarind, that its leaves embrace the tender pods.

This opinion *Ray* diſclaimed, though he allowed the fact: but you have adopted it. I think it will appear upon a ſtrict examination, that the change itſelf is a natural effect, reſulting from the common properties of bodies, and their operations upon one another; and that the author of nature has in many inſtances made it effectual to that great purpoſe; though in others it happens equally, without anſwering ſuch end.

We ſee how far the obſervations of earlier writers carried the diſcovery; how much farther your own: and I perſuade myſelf you will accompany me with ſatisfaction in a more deep reſearch.

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* Glycine foliis pinnatis conjugatis, pinnis ovatis oblongis, obtuſis.

You

You have deſerved greatly of the world in this and other inſtances, by tracing nature's ſteps, and recording thoſe obſervations. To relate theſe facts is to give the hiſtory of nature: but there is ſomething more within our reach: The human mind, daring, though weak, and inquiſitive under all its limitations, ſeeks, and ſometimes not unhappily, their cauſes.

There have not been wanting from the time when this property in vegetables was firſt regarded, ſome who have ſought its origin; but all yet unſucceſsfully. Thoſe who ſuppoſed it the effect of heat and cold, might for a long time ſeem to have judged rightly; but when we find the ſame thing happen with equal regularity in ſtoves, where there is no change in the temperature of the air, we are convinced that opinion cannot be juſt.

They were as far from truth, who ſuppoſed the health or ſickneſs of the plant of any conſequence in this reſpect; nor can I affirm that I have found nature in all inſtances confirm your obſervation, that it is more obvious in young plants than old.

It will appear from the following trials, that the ſleeping and the ſenſitive plants are naturally allied; that their motions, though differently brought on, are dependent on the ſame principle; that many of the ſleepers approach to the quality of the ſenſitives; and that all the ſenſitives have theirs.

This will ſhew the ſubjects are connected, and the principal experiments will prove, that, with

with this connection, the principle of their motion is alſo found.

If I can cloſe the Abrus leaves at noon-day, and open them again at pleaſure, you will own, I know the principle of their change of poſition.

If I can throw down, as well as cloſe the leaves of the ſenſitive plant, without a touch, by removing the power which keeps them erect, and expanded, you will acknowledge the latent principle of their motion is alſo underſtood.

We always know the cauſe of thoſe effects we can ourſelves produce; and experiments are the true teſt of reaſoning.

SECT. II.

We ſee a great number of plants cloſe their leaves at evening. The fact is as obvious as it is ſtrange: but we know every effect has its cauſe; and we are to ſeek this, not by vague conjecture, but in the eſtabliſhed properties of bodies, and their known influence, in different caſes, upon one another.

The ſtructure of plants we may eaſily know; and of no part more perfectly than of the leaves: for a good microſcope ſhews their ſmalleſt veins.

Between the two ſkins of the leaf, which are continuations of the outer rind of the ſtalk, there run innumerable fibres of a larger kind; with cluſters of more minute ones, in various forms among them.

The large veſſels are of a woody ſubſtance; hollow; and ſmaller all the way from the baſe of the leaf: they are collected together in a compact manner in the footſtalk; with delicate cluſters at its baſe: and they are originally ſent from the ſtem.

They ſerve to ſupport the leaf in its proper poſition; and therefore whatever external or internal cauſe affects them, will change that poſition.

This is the conſtruction of the part to be influenced; the queſtion remains, what it is that affects it; and to know that we are to examine whatever may have ſuch power.

Leaves thus conſtructed are always ſurrounded by the air; and they are occaſionally and variouſly influenced by heat, light, and moiſture: The air alſo itſelf being in a continual ſtate of variation, its alterations are to be conſidered as poſſible ſubordinate cauſes of change.

Theſe things, and theſe only, come within contact of plants, or within the ſphere of influence. Bodies do not affect bodies, but on contact, or within that ſphere: therefore the cauſe of the change of poſition in leaves, is to be ſought among theſe agents, and no other.

They are naturally complicated, and they act on moſt occaſions together. We are therefore to obſerve, firſt, what effects reſult from their mutual combinations in a ſtate of nature: and having aſſigned in theſe caſes the effect to the proper and particular cauſe, from this power of that agent, whichſoever it is, that acts

acts thus in concert with the reſt, we may deduce its operations ſingly.

SECT. III.

Pinnated leaves, ſuch as are compoſed of numerous lobes, or ſmaller leaves placed on a common foot-ſtalk, are moſt remarkable for their change of poſition: it will be therefore beſt to wave all other conſideration here; and obſerve ſolely the condition of theſe.

The four agents we have named are univerſal; but we ſhall find their operation differs in various climates. In theſe temperate kingdoms, our native plants which have pinnated leaves, naturally hold the lobes nearly horizontal, and ſhew but a moderate ſenſibility in this reſpect; in the hotter regions of the Eaſt, the uſual poſition of the lobes in theſe plants is turning upwards, and they are extremely ſuſceptible of change of poſture; in *Ægypt* moſt of all: in the more northern nations, on the contrary, they ſcarce ever reach an horizontal poſition, and they ſhew very little change on any occaſion.

As we ſee different appearances in theſe parts of plants in hot, temperate, and cold climates; obſervations of a like kind ſhew, they are not leſs variouſly affected in the ſame kingdoms in rainy and fair ſeaſons. In thoſe places where there are regular periods of rainy weather, the change in the face of the pinnated plants is very great, and certain: Thoſe which in the fair months carry their lobes in

an obtuſe angle upwards, conſtantly hang them obtuſely downward in the time of the rains.

Theſe are the obſervations of curious voyagers; and they have been confirmed by the immediate notice of botaniſts in thoſe places. The firſt would ſeem at once to give the effect to heat; and the other to moiſture: but farther obſervation ſhews it is otherwiſe. You have juſtly obſerved, that the ſame thing happens to plants in the ſtove, where there is no alteration in point of heat; and I have found by careful trial, that moiſture has in the ſame reſpect no effect: I have for this purpoſe watered ſome plants almoſt to deſtruction, and left others of the ſame kind dry; and no alteration has been made by this: They all expand, or raiſe their leaves in the morning, and drop them in the evening; at the ſame hour and in the ſame degree.

Two of the four natural agents, heat and moiſture, are therefore excluded from any ſhare in this effect: the air is too univerſal, and its changes too much depend on theſe, to be admitted in the reſearch. The attention therefore falls on light alone: and I have found by many experiments, that the change of poſition in the leaves of plants at different periods of the day and night, is owing to this agent and no other. This is the diſcovery I perſuade myſelf I have made; and I ſhall endeavour to ſhew, that it is founded on reaſon, and ſupported by experiments.

Nor is there any thing ſtrange in the effect, when duly examined. By excluding the ſuppoſed cauſes, we have diſcovered the real, for

there

there remained no other: and in examining the ſubject, on the principles here laid down, we ſhall find not only that no other power could produce the effect; but that light inevitably muſt.

Theſe are the diſcoveries on which the everlaſting ſeal of truth is ſtamped; which reaſon dictates; and which experiments confirm.

SECT. IV.

We have propoſed to ſearch the latent principle of this change in the qualities of bodies, and their natural operations upon one another.

We have ſhewn what is the ſtructure of leaves in general; and it will now be proper to fix on ſome one in particular: Let us chuſe for this purpoſe an *Egyptian* plant, ſince thoſe ſhew the effect moſt of all; and among theſe none can be more proper than the Abrus, celebrated for it by the earlier writers.

The leaf of this plant conſiſts of thirteen pair of lobes, fixed by very ſhort and extremely ſlender footſtalks to the middle rib; and this to the main ſtem of the plant.

Examining its internal ſtructure by the microſcope, we find a number of delicate fibres, riſing from the central part of the main ſtem, and continued in a courſe obliquely upwards, through the intermediate parts, and to the out-ſide of the rind. Here they ſwell; and run into ſeveral regular cluſters, ſpreading downward and on each ſide; and theſe form (under the continued covering of the ſtem) the baſe

baſe of the common footſtalk, or middle rib of the leaf.

From this part they are carried in a ſmall compacted bundle, ſtrait forward to the extremity of the rib; and there, as there is no odd lobe to cloſe the leaf, they terminate in a point, covered by the common integuments.

From each ſide of this middle rib riſe the footſtalks of the ſeparate lobes. They are formed of a multitude of delicate veſſels, ranged cloſe together, and confined by the covering, which is the common rind of the plant continued to that part.

At the baſe of each lobe there is another complex cluſter of fibres. From this part they are protended forward, ſtrait to the end of the lobe; and they ſend out only ſlight branches into the ſeveral parts of the leaf.

This is the particular fabrick of the Abrus leaf, as ſeen upon a careful diſſection, and with a good microſcope: it agrees with the general conſtruction, we have given before, as the common courſe of nature in theſe parts; and it will regularly explain the change of poſture in the lobes, under the different influence of light.

Light is ſubtile, active, and penetrating; by the ſmallneſs of its conſtituent parts, it is capable of entering bodies; and by the violence of its motion, of producing great effects and changes in them. Theſe are not permanent, becauſe thoſe rays which occaſion them, are, in that very action, extinguiſhed, and loſt.

Bodies may act on light without contact; for the rays will be reflected when they come extremely

extremely near: but light can act on bodies only by contact; and in that contact the rays are loſt.

The change produced in the poſition of the leaves of plants by light, is the reſult of its motion occaſioned by its rays among their fibres: to excite this motion, the light muſt touch thoſe fibres; and where light touches, it adheres, and becomes immediately extinguiſhed.

SECT. V.

Theſe are the everlaſting and invariable properties of light: and, according to theſe, the change we attribute to it, being once effected, muſt be continued as naturally and as neceſſarily as it began, ſo long as the light continues, and no longer.

The raiſing of the lobes in theſe leaves will be owing to the power of thoſe rays which at any one inſtant fall upon them: theſe become extinguiſhed; but others immediately ſucceed to them, ſo long as the air in which the plant ſtands, is enlightened. It ought therefore to be ſeen, that in full light, the lobes continue in their moſt raiſed poſition; and that they droop from that in proportion as the light becomes leſs.

This which appears neceſſary from the powers of light, and the conſtruction of leaves, is true alſo in fact.

We have ſeen that the footſtalks of theſe lobes, are cluſters of fibres protended from the center of the ſtem; that they are continued

through

through the lobes; and that they ſupport them in their poſition, whatſoever it is.

The effect of light upon theſe fibres is the putting them into an inceſſant vibration: This happens neceſſarily from the continual impulſion and extinction of the corpuſcles, of which light is compoſed, and the freſh impulſion of others, upon the extinction of the firſt.

It cannot be, but that a cluſter of delicate fibres, affected inceſſantly by theſe concuſſions, muſt be put into a vibrating motion; and this will be greater, as the light is more, and weaker as it is leſs.

This vibration is ſimple in the expanded fibres; but it operates as variouſly as diſtinguiſhably on thoſe cluſters of them which are placed at the baſes of the main rib, and of the ſeveral footſtalks of the lobes.

It is on the operation of light upon theſe interwoven cluſters of fibres, that the motion of the leaves in gaining their different poſition depends; and conſequently, the motion itſelf is various, according to the conſtruction of thoſe cluſters.

In the Abrus they are large, and of a lax compoſition; conſequently the lobes are capable of a drooping, an horizontal, and an oblique upward poſition: in the Tamarind, and the broad-leaved Robinia, they are more compact, and hence all the motion of which thoſe leaves are capable, is an expanding open, and a cloſing ſideways; which the direction and courſe of the fibres alſo favours; in the *Parkinſonia* they are ſmaller, and yet more compact;

pact; and the conſequence of this is, that its lobes have no farther poſſible motion, than the expanding and cloſing upwards.

Hence the effects of a full light are different on various of the pinnated leaves; raiſing the lobes of ſome, as the Abrus, and opening or expending thoſe of others, as the *Parkinſonia.*

The impulſe of light, and the vibration it produces, are the ſame in all theſe inſtances: but the direction of that motion into which the lobes are thrown, is according to the courſe of the fibres; and the quantity of it, in equal degrees of light, to the conſtruction of thoſe reticulated cluſters.

This univerſally appears on examination of the cluſters of fibres by a microſcope, and obſervation of the motion of the lobes: that motion being univerſally of greater extent, where the cluſters of fibres are longer, and more looſely interwoven; and of leſs, where they are ſhorter, and more compact.

The effect of light upon bodies we ſee is to put their parts into a vibrating motion; the conſtruction of pinnated leaves is ſuch as naturally admits and propagates that influence; and the cluſters of fibres are as a kind of joints on which their lobes are capable, under the influence of light, of a certain limited motion.

As the ſtate of water uninfluenced by heat is ice, the natural poſition of the lobes in theſe pinnated leaves is drooping. This is their poſture of repoſe: but in this they were not intended by the author of nature to re-

main; for vegetation is very imperfectly performed, while they are in it.

The effect of light is this vibration, and the alteration of position in those lobes. This is the doctrine here advanced, and this is supported by the following experiments.

SECT. VI.

I removed a plant of the Abrus from a stove, in the evening of the seventh of August, and placed it in my study, where it could have the effect of moderate day-light, without being exposed to the immediate action of the sun.

This might be conceived the most natural and equable degree of light; and therefore fittest for the first experiments.

The lobes of the leaves were at evening, when the plant was brought in, fallen perpendicularly from the middle rib, and closed together by their under sides.

Thus they continued during the night; in a state of perfect repose. Half an Hour after day-break they began to separate; and in a quarter of an hour after sun-rise stood horizontally; flat, and perfectly expanded. Long before sun-set they began to droop again; and toward evening they were closed underneath, as at first.

Next day the plant was set in a room where there was less light. The lobes were raised in the morning; but not to a horizontal situation; and they drooped earlier at evening.

The

The third day it was ſet in a ſouth window, open to the full ſun. Early in the morning the leaves had attained their horizontal ſituation; by nine o'clock they were raiſed conſiderably; and they continued in this ſtate till toward evening, when they by degrees fell to the horizontal ſituation; and from that drooped gradually to the uſual ſtate of reſt.

The fourth day the plant ſtood in the ſame place, but the ſun did not appear. The lobes obtained early their horizontal ſituation, but did not riſe beyond it; and in the evening cloſed as uſual, below.

SECT. VII.

Theſe experiments ſhew the effects of various degrees of light: at the ſame time, that they prove the whole change to be occaſioned by light only.

The effect of moderate light, that is, the light of a bright day out of the ſun-ſhine, is to raiſe the lobes to an horizontal poſition: Leſs than this places them at an obtuſe angle downwards: more, at an obtuſe angle upwards.

The fifth day the plant was ſet in a leſs enlightened room: and the leaves had obtained by nine o'clock their poſition at an obtuſe angle downward: it was then brought into the lighter room, and they roſe to the horizontal ſituation in a quarter of an hour. It was then removed to the window, where the ſun ſhone, and the lobes were elevated as

before; and being thence carried into the leſs light room, they drooped again. All theſe changes were produced between the hours of nine and two, the weather the ſame, and only the place of the plant changed.

On the ſixth day it remained in moderate light; and kept its leaves horizontal.

On the ſeventh I made the final experiment.

It appeared to me, that if light were the ſole cauſe of the motion, and change of poſition in the leaves, then denying the plant the benefit of light at any time, muſt bring on that change: that it would not be difficult to darken the place where the plant ſtood, at any time: and that the conſequence of this muſt be, if the principles already laid down were true, a bringing on of the change at any time of the day. This experiment appeared as a juſt proof of the foregoing reaſonings: if darkneſs would at any time throw down the lobes, the ſyſtem of that motion before delivered muſt be true; if not, that all the reaſonings muſt be falſe.

The aſſent of the world muſt alſo depend on this. Deductions of reaſon may be diſputed, but it will be allowed certainly, that we underſtand the cauſe of a change we can produce.

In the evening of the ſixth day I ſet the plant in a book-caſe, on which the morning ſun ſhines; and throwing open the doors, left the whole to nature. The ſucceeding day was bright. The lobes which had met in their

their drooping poſition at evening, and continued ſo during the night, began to open early in the morning, and by nine o'clock they had paſſed their horizontal ſituation, and were elevated in the uſual manner.

I then ſhut the doors of the book-caſe: the plant was by this left in darkneſs; and on opening them an hour afterwards, the full change had happened: the lobes were all dropped, and it was in the ſame ſtate that it would have ſhewn at midnight.

On the opening of the doors the change began very ſoon: and in twenty minutes the lobes had obtained their elevated ſituation. This experiment I have ſince many times repeated, and always with the ſame ſucceſs.

It is in our power therefore to bring on this ſtate of repoſe at pleaſure; and by the admiſſion or excluſion of light, to make the plant at our own time put on all its changes, from the drooping to the moſt elevated poſition of the lobes.

We know that in theſe experiments, light alone is the cauſe: we are therefore certain, that what is called the ſleep of plants, is the effect of the abſence of light alone, and that their various intermediate ſtates are owing to its different degrees.

SECT. VIII.

This being explained, a ſecond diſcovery follows naturally. The motion of the ſenſitive plant, at the cauſe of which no philoſopher

pher has hitherto ventured a conjecture, is in a great meaſure owing to the ſame principles: and the explanation of it, which before the effect of light upon the leaves of plants was thus ſhewn, muſt have been inveloped in impenetrable obſcurity, may now be regularly purſued.

The ſenſitive plant, beſide its ſingular quality of cloſing and dropping its leaves upon the touch, is ſubject to the ſame changes with the Abrus, and thoſe other kinds, we have named from the effect of light.

Theſe natural, as well as the accidental motions on the touch, I have traced regularly in the common ſenſitive plant: but before we enter on the detail of thoſe obſervations, it will be proper to remark, how nearly ſome other plants approach to the quality of this, and the other ſpecies of ſenſitive; which they have been hitherto ſuppoſed to poſſeſs alone.

This ſurprizing quality is a power of motion in the lobes and their footſtalks. No change of poſition can be made without motion of the parts, therefore the Abrus, and all theſe other plants have alſo motion.

They agree with the ſenſitive in diſplaying this motion from the power of light; and all that remains particular in the ſenſitive is, that it is capable of the ſame motion from another cauſe. This is an accidental ſhock of its parts.

SECT.

SECT. IX.

Even that is a quality common to ſome other kinds, though in an inferior degree: for a Tamarind tree has lately under my obſervation, cloſed its leaves on motion.

A flouriſhing plant of this, a yard high, being brought from Mr. Lee's nurſery at Hammerſmith, to me in St. James's Street, in the middle of the day, came in with its leaves cloſed, as it naturally has them at midnight, and as the ſenſitive plant on being touched.

An Abrus ſuffered no change under the like circumſtances.

Hence we infer, that the ſame conſtruction of parts, which gives the ſenſitive plant the power of motion, is in the Tamarind tree, though leſs delicate; ſo that a ruder ſhock is required to bring on the change.

It is in a lower degree alſo in the Abrus, for light has that power, though the effect cannot, ſo far as we have yet ſeen, be produced by a ſhock.

Plants which ſuffer this change from the effect of light, may, though they do not univerſally, ſhew it alſo from motion; and all plants which are capable of this change by motion, ſuffer it alſo from the abſence of light.

Light gives their leaves that poſition, from which they are to be thrown by a touch: and the abſence of light takes the ſame effect with that touch; though in a ſlower manner.

The

The ſenſitive plant at noon-day has its leaves raiſed and expanded. The footſtalks make an acute angle with the main ſtem, and the two leaves which grow on each of the firſt or lower ones, ſtand remote from one another. The lobes which compoſe theſe, are about twelve pair to each, and theſe alſo ſtand in an horizontal direction.

Thus the young plant appears in the middle hours of day. At the approach of evening, the lobes begin to draw themſelves together upwards, as in the *Parkinſonia*; and the middle rib of each approaches toward the other: at night the lobes are as entirely ſhut upwards, as thoſe of the Abrus downward, the two ribs are placed cloſe to each other; and the footſtalk which ſupports them both, hangs down.

This is the ſtate of repoſe of the ſenſitive plant: into this it falls every night naturally; and into this it may, in the ſame manner as the Abrus, be thrown at noon-day in a darkened place.

SECT. X.

As we have ſeen the cauſe of this change in the Abrus to be light, and have traced the manner of the operation; it is eaſy to follow it alſo in the ſenſitive plant, through the ſame courſe of enquiry.

At the baſe of the footſtalk, where it joins the main ſtem, there is a cluſter of complex fibres: Theſe have riſen from the inner part, and pierced the woody ſides.

From

From this complex cluſter, the fibres proceed in a ſtrait line up the footſtalk, till at the head of that, where the two leaves riſe, there is another ſuch cluſter: thence the fibres run ſtrait the length of the main rib, and ſend out on each ſide other cluſters at the baſe of every lobe. From theſe more minute fibres run ſtrait through the leaf, and ſend out lateral ſhoots.

This the microſcope diſcovers plainly; and this ſhews that not only the natural motions of the ſenſitive plant are the ſame with thoſe of the Abrus and others, but that the conſtruction alſo is the ſame in its kind, though more complex.

In the night the ſenſitive plant is not capable of the common motion on the touch, for the leaves are already in the condition whereto they would be reduced by it. In the day they riſe and ſpread: and 'tis then the ſtrange effect appears on touching them.

Light expands the lobes, ſeparates the ribs, and raiſes the footſtalks. It does this, by putting all the parts of them in a vibrating motion. This we have ſeen in the Abrus, is principally effected by means of thoſe cluſters of fibres which are placed at the baſes of the footſtalks. In this plant, as there are no leſs than three ſets of thoſe cluſters, the effects of the ſame principle are naturally much greater than in the Abrus, where there is only one.

The vibration of the parts is that which keeps the leaves of the ſenſitive plant in their expanded and elevated ſtate: This is owing to a delicate motion continued through every

fibre of them. When we touch the leaf, we give it another motion more violent than the firſt: this overcomes the firſt: the vibration is ſtopped by the rude ſhock: and the leaves cloſe, and their footſtalks fall, becauſe that vibrating motion is deſtroyed which kept them elevated and expanded.

That the power of motion in the ſenſitive plant depends upon the effect of light on the expanded ſurface of the leaves, is certain; for till they are expanded, they have no ſuch power. The young leaves, even when grown to half an inch in length, have no motion on the touch, though rough and ſudden.

To propagate the motion when the leaves are in a ſtate to ſhew it, there requires a perfect and confirmed ſtate of thoſe cluſters of fibres lodged at their baſe. This is evident: for when the young leaf has firſt come into the ſtate of vibration, a touch will make its lobes cloſe; but the effect is not continued down the footſtalk, till it is more confirmed. No ſhock on the young leaf will affect the footſtalk before it is expanded: hence the cluſters of fibres at the baſes of the lobes firſt acquire their due condition for motion; and afterwards thoſe at the head of the main footſtalk.

As there requires a due firmneſs to give the cluſters of fibres the ſuſceptibility of motion, and power of propagating it farther; there needs alſo a concurrence of favouring circumſtances, to preſerve them in that delicate ſtate wherein they are capable of exerting theſe powers.

The

The cold air hardens the fibres and impairs their ſuſceptibility of motion. The ſenſitive plant becomes more languid in this reſpect when removed out of the ſtove.

The correſpondence between this motion, and what you have called the ſleep of plants, or their natural cloſing of their leaves at night, appears alſo in this inſtance: for as the ſenſitive by being removed out of the ſtove, loſes in ſome degree the quality of cloſing its leaves on the touch, the Tamarind by the ſame change loſes in great part its quality of cloſing the leaves at evening. This is probably owing to the juices ſtagnating in the cluſters of fibres, and to the contraction of the bark by cold.

The communication of motion is leſs from the lobes to the footſtalk; and greater from the footſtalk to them. The greateſt ſhock is given to the plant by a rude touch of the ſtem: but even this does not affect the unexpanded or young leaves.

The analogy between the effect of a ſudden motion, and of the abſence of light is confirmed alſo by this; for as light decays naturally at evening, or artificially by ſhutting up the plant, the lobes firſt cloſe, and the footſtalks afterwards fall.

The power of abſolute darkneſs is greater on the ſenſitive plant, than that of the rudeſt touch. The rudeſt touch will only cauſe the lobes of the ſeparate leaves to cloſe, and the footſtalks to hang down: the two leaves will remain far aſunder. The effect of abſolute darkneſs exceeds this; for the two leaves

cloſe alſo abſolutely together, and it appears as if the footſtalk ſupported only one. This proves that the expanſion of thoſe parts depends ſolely upon the effect of light; and that although it may be diſturbed by a ſuperadded and ruder motion, yet it can be taken away abſolutely only by darkneſs; by the defect of that to which alone it was owing.

Theſe experiments every one may eaſily repeat: the obſervations will be familiarly made by any who have ſtoves: They are conſtant and invariable; and the concluſions from them are certain; for no other cauſe intervenes.

The effect of light is continual while the light continues. The plant therefore whoſe leaves have been thrown down, and cloſed by this rude ſhock, is immediately affected by the light, as at its firſt appearance in the morning, or as on its admiſſion, when the leaves had been cloſed by artificial darkneſs. The vibration begins; and if the light be at its full ſtrength, the expanſion and elevation of the lobes is ſo quick, that one may almoſt look upon the plant, and ſee it. A few minutes often perfects it.

That the touch of the leaves no other way affects them than by a motion greater than their own internal vibration, is plain from this, that if they be touched with a finger in ſo deliberate and gentle a manner as not to move them, no effect is produced: and on the other hand, if they be any other way moved, the full effect follows.

If the pot be ſhook, though no part of the plant be touched, the leaves cloſe, and their footſtalks fall: or if the wind blow them, the effect is the ſame.

Hence it is certain that the expanſion of the lobes, and elevation of the footſtalks in theſe pinnated plants, is occaſioned ſolely by that vibrating motion, in which their parts are kept by the continual impulſes of light: and conſequently that in all of them they collapſe or ſink on the abſence of light; and in the more delicate kinds upon the ſhock of any ruder motion, which for the preſent ſtops that vibration.

Hence alſo the different appearance of pinnated leaves in various climates is underſtood; and may be aſſigned to its true cauſe, which is the different degree of light.

In the Eaſt the lobes are expanded, not becauſe of the heat, but becauſe the light is ſtrong: In the northern kingdoms they droop, not from cold, but becauſe the air is leſs enlightened: In the rainy ſeaſons they alſo droop, but it is not from the moiſture, but the darkneſs of the weather; and in *Ægypt* they are moſt raiſed of all, not becauſe it never rains; but becauſe the light is conſtant.

The Abrus placed in a ſouth window perfectly ſhews this; for the expanſion and elevation of its leaves is proportioned always to the degree of light, and conſequently it is affected by the cloudy or clear weather, though the plant remain in the ſame place.

The

The lobes begin to riſe before the ſun is above the horizon, becauſe the air is enlightened in a proportioned degree; and they begin to cloſe again long before it ſets, becauſe in the ſouth window the ſhadow of the building darkens the air about them.

In the rainy weather which we have now lately had, the leaves wore the ſame appearance they would have done in a plant native of a country where there are ſeaſons of rain; they never at any time of the day reached the horizontal poſition, and they drooped much earlier in the afternoon, and began to expand much later in the morning.

The ſenſitive plant which was placed near the Abrus, was affected in the ſame manner: and by repeated and careful examination, I have always found, that in both theſe and in all others, the degree of elevation or expanſion in the lobes, is exactly proportioned to the quantity of light; as it is ſolely dependent on it.

When the ſenſitive plant has been kept out of a ſtove ſome days, and has loſt ſome part of its power of motion, if the leaf be touched ſoftly, and the force encreaſed gradually, it will bear a great deal without drawing up the lobes; but at the ſame time a much leſs preſſure given with a ſudden ſtroke will occaſion their cloſing.

In this manner we may alſo trace the extent and progreſs of the motion according to the force; a ſlighter ſhock raiſing only the lobes that are touched, a harder the oppoſite ones, and ſo the whole.

This quality in the leaves of plants, as their general ſtructure is the ſame, and the ſame agent operates univerſally, ought to be found in all; though in various degrees, according to the conſtruction of their parts. In this, as all the preceding inſtances, juſt obſervation confirms the principles deduced from reaſon. In ſome it is greater, in others leſs; in many obvious to the common eye, in others difficultly perceived by the moſt accurate; but on a ſtrict and cloſe examination, I have not found any plant or tree wholly deſtitute of it.

SECT. XI.

That the curious who ſhall chuſe to repeat the experiments mentioned in the preceding pages, may find no difficulty in that reſpect, I ſhall give the particulars of the plants, and apparatus with which I made them.

The Abrus, Senſitive, and Tamarind, I obtained, in pots, from the nurſery of Mr. Lee, near Hammerſmith: a perſon whoſe induſtry and knowledge in his buſineſs, will ſome time make him known, to his advantage.

The microſcopes were thoſe of Mr. Cuff.

The Abrus was a flouriſhing plant, of two feet and a half high: the Tamarind ſomething taller. The Senſitive was a young one; in which ſtate there are only two pinnated leaves upon each footſtalk.

A plant of this growth is moſt manageable out of a ſtove, and was preferred for that reaſon;

ſon; but the ſame experiments made on thoſe of larger growth, anſwer in the ſame manner.

The place where they were kept, unleſs when removed for the particular experiments which required it, was a ſouth window.

The Abrus will live very well in ſuch a ſituation at this ſeaſon of the year; and the Senſitive, with due care, may be kept in tolerable perfection in the ſame manner, a fortnight or three weeks; though much more tender than the other.

The apparatus for the experiments, beſide the microſcope, conſiſts only of a fine penknife, and a flat board, covered with a piece of cork, ſix inches long, and three broad.

In order to trace the courſe of the fibres, and ſee their cluſters diſtinctly, a leaf of the Abrus muſt be pulled off, by ſlipping it downward. This brings away its baſe entire, and is neceſſary for obtaining in perfection the cluſter which is ſituated there.

The leaf muſt be laid flat upon the cork, and fixed down by a ſmall pin, thruſt through the middle rib, a little above the place where the firſt pair of lobes are inſerted.

There muſt be a good light, and a careful ſteady hand, and the point of the penknife muſt be kept ſharp and clean.

It will be eaſy to let this in at the middle of the rib, a little above the inſertion of the firſt lobes, and to ſplit the rib thence equally to the baſe.

The object is neither too minute for the hand, nor the eye; nor does it require thoſe powerful

powerful magnifiers, which are often needful in the more delicate reſearches.

The cluſter of the fibres at the baſe of the main footſtalk, will be thus ſeen: they will appear cut more or leſs exactly in two, according to the diviſion of the ſtalk, and their courſe and interwoven texture afford a pleaſing object.

This is the firſt expermiment to be made; and it is very happy that the conſtruction is ſeen without great difficulty, for it leads the way to the reſt, which being minute, require a more ſtrict ſcrutiny.

The courſe of the fibres along the middle rib, and their cluſtering at the baſes of the lobes, may be purſued by ſplitting the footſtalk farther up: but as this is not eaſily done, I have been uſed to cut off the upper and under part of the leaf, and leaving only a piece, which has one pair of the lobes, and to cut it acroſs in the centre of their baſes.

This requires a careful eye, and a very regular preſſure of the penknife; but with ſo much caution, it may always be done ſucceſsfully.

At the baſe of each lobe there will be ſeen a cluſter, in all reſpects reſembling the firſt, only more delicate; and from that the fibres will be found continued in a ſtrait courſe along the middle rib, as they are in the ſame way along the footſtalk, from the firſt cluſter.

This way the eye perceives that there are ſuch fibres, that they are ſo cluſtered, and that their courſe is regular from thence. The fact is ſo aſcertained, but to admire duly the con-

ſtruction on which this motion depends, the fibres muſt be ſeparated from all ſurrounding matter, and laid before the double microſcope in water.

The method is this:

Let a leaf be pulled from the Abrus, as before, and in the ſame manner cut into two or three ſhort pieces; two lobes remaining with each: let the footſtalk be ſplit firſt at the baſe, and afterwards croſswiſe at each joint; thro' the baſes of the two lobes, and into the centre of the middle rib of each.

Let the ends of the lobes be cut off; and a number of theſe pieces be put into a ſaucer of water, keeping them down by ſome little weight.

They muſt lie in this water two or three days, according to the warmth of the weather; and at the end of that time they muſt be preſſed gently againſt the bottom of the ſaucer, with a piece of muſlin tied to the end of a pen, or other ſuch implement.

This muſt be done with a delicate hand, and repeated often. They will be thus cleared from all ſurrounding matter. The firmneſs of their own texture will preſerve them. They muſt be afterwards put into freſh water, and left four or five hours to ſwell and recover their firſt diſpoſition; and then laid in water before the double microſcope. The courſe of their fibres in their ſimple and cluſtered ſtate, will be thus perfectly ſeen, and the mechaniſm by which the motion in the lobes is performed eaſily underſtood.

The

The method with the Senſitive plant is to be exactly the ſame. The footſtalk ſupporting the two leaves, muſt be torn off downwards, and the leaves expanded on the cork with pins, as directed for the other. The baſe of the footſtalk muſt firſt be ſplit with the penknife; then the baſe of each leaf on the head of this ſtalk, and after that the baſe of each lobe. The conſtruction in this part is very obvious, for it ſwells up extremely, and appears as a kind of joint, to ſerve the motion.

The condition of the cluſters of fibres when the footſtalk is juſt ſplit, is more or leſs diſtinctly ſeen according to the age of the plant, the place of the leaf, and the degree of nouriſhment. It is moſt diſtinct in a leaf taken from the lower part of a young plant; but not the loweſt, or any placed ſo low as to be fading: and in the ſame manner the conſtruction at the baſe of the lobes is beſt ſeen in the ſecond pair from the baſe of the footſtalk.

Theſe directions will be uſeful to thoſe who will not be at the pains to clear the parts in water: but that way there is no difficulty in bringing the whole plainly and perfectly to view. I am,

With great reſpect,

SIR,

Your Humble Servant,

London,
Sept. 7,
1757.

JOHN HILL.

INDEX of the Sections, with their CONTENTS.

FINIS.